Engineering curricula modernization in renewable energy in Albanian Universities

ENGINE

Project reference No. 619338-EPP-1-2020-1-AL-EPPKA2-CBHE-JP

(Deliverable 1.3)

Report on the best practices in Program HEIs and global trends

Nisan, 2021

Co-funded by the Erasmus+ Programme of the European Union

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Abbreviations

AAAI- Association for the Advancement of Artificial Intelligence
ACM- Association for Computing Machinery
ACT - American College Testing
APS- American Physical Society
DigSLIENT - DIgital SImuLation of Electrical NeTworks
EEE- Electrical and Electronics Engineers
EPFL- Swiss Federal Institute of Technology Lausanne
ETAP - Electrical Transient and Analysis Program
ETH - Swiss Federal Institute of Technology
EU - European Union
HEI - Higher Education Institution
IEEE - The Institute of Electrical and Electronics Engineers
IELTS - International English Language Testing System
KAIST - Korea Advanced Institute of Science & Technology
KHAS – Kadir Has University
MATLAB – Matrix Laboratory
MIT - Massachusetts Institute of Technology
NTU - Nanyang Technological University
PSCAD - Power System Computer Aided Design
PSS/E - Power System Simulator for Engineering
PLS CADD - Power Line Systems - Computer Aided Design and Drafting
RED - Radio Equipment Directive
SAT - Scholastic Assessment Testing
SCADA - Supervisory Control and Data Acquisition
STEM - science, technology, engineering and math
UET - European University of Tirana
UAMD - Aleksandër Moisiu University of Durrës
UK – United Kingdom
US – United States
UCLA - University of California, Los Angeles
TOEFL - Test of English as a Foreign Language

Summary

This document presents the main findings of the desk research related to the ENGINE project in Albanian HEIs. This deliverable thus corresponds to task D.1.3. of WP1: "In-depth desk research assessment and report for Albania and partner HEIs", led by KHAS and co-lead partner UAMD.

Following are highlighted the major pillars of the desk research:

- Best practices have been considered throughout the world, especially in Europe, when considering electric engineering departments in terms of all aspects.
- Curriculum and career opportunities run by departments of universities with good practices
- Entry requirements for departments, exams, job opportunities for graduates, average salaries
- Used IT tools and recommended new tools
- Opportunities that departments should have in the future, and suggestions for all of these have been researched in terms of ENGINE project.
- Evaluation of the situation of electrical engineers in terms of education, opportunities, improvements and requirements for the energy sector.

1. Introduction

Energy is an exciting challenge for universities today because of the need for multi-disciplinary collaboration in research and innovation and for new approaches to help professionals entering the energy sector acquire skills and knowledge. We need young people with bright ideas to break away from conventional thinking and establish new expertise. Science will continue to develop technological breakthroughs that advance the transition from fossil fuels to renewable energy and universities can provide the right environment for nurturing and bringing such expertise to fruition. Universities have a critical role to play as key stakeholders both in the energy market and among all stakeholders. Ultimately, universities build capacity through the development of new knowledge and new insights and therefore can provide effective solutions to complex energy problems. They also ensure a regular supply of highly educated, talented people who develop and implement solutions to energy and other social challenges. Universities are uniquely positioned to make a significant contribution to projects such as ENGINE, as they are able to combine expertise from different research and educational disciplines and consequently provide a bias-free environment for discovering and developing new ideas. As researched in the ENGINE project, interdisciplinary approaches will be required for energy-related departments, particularly the curricula for renewable energy courses. Thus, different energy technologies, systems, economies and markets, new regulatory frameworks, consumer behavior insights, and human resources will be trained according to the needs of the market to solve the current challenges holistically.

The objective of this report is to provide the necessary support for the ENGINE project to achieve its goals by scanning universities across the world, especially in Europe, and determining best practices, and providing participation in the curriculum of the relevant universities in Albania.

1.1 The importance to match current education offer in electrical engineering with the job market

As the emergence of advanced technologies such as artificial intelligence is reshaping all sectors in the market, new approaches are needed to help manufacturing companies get ready for the future. Digital transformation offers great opportunities for manufacturing in terms of creating sustainable value along with economic, environmental, and social criteria. Advanced technologies support the creation of more tangible products with fewer resources by transforming manufacturing processes in order to increase the use of resources in multiple life cycles of products. Digital transformation is one of the enablers of sustainable manufacturing which the majority of business leaders predict benefits through it for manufacturing companies worldwide. The digital transformation of manufacturing forces employees to adapt their working habits. This adaptation also requires a change in learning and teaching approaches for training employees.

As the global job market has already acknowledged electrical & electronics engineering and employed engineers in a wide range of sectors, their responsibilities and tasks change depending on current needs of the market. At present, the fourth industrial revolution, also called Industry 4.0, provides a major opportunity in terms of competitive advantages and new business models. For instance, meeting the sustainability challenge has raised attention by adapting value creation networks to seize such opportunities. Therefore, adequate education and training are necessary to adapt electrical & electronics engineering to the fourth industrial revolution.

The ongoing revolution promotes the combination of physical systems embedded with electronics, software, and sensors. In order to enable the combination through digital data, automation, connectivity, and real-time access, implementation of advanced technologies such as artificial intelligence is needed. The emergence of new technologies and structural changes in value creation requires a digital transformation. Some major requirements are standardization to ensure interoperability between different systems, cooperation on sector-specific integration platforms, and data security during intellectually collecting and exchanging data.

Many companies and their employees need to adapt ongoing manufacturing activities including responsibilities, deadlines, and tasks within this new framework in a few years. The adaptation may have different causes and effects and contains different planning cases in an emerging field. The educational organization's approach to work conditions is gradually paving ways for more job demands from employees. Selected employees of a manufacturing company can build a team, which is responsible for such transformation projects. The goal of these projects includes accomplishing transformation tasks by utilizing methodologies of project management such as the guideline for factory planning.

However, internal resistance is currently one major limitation for a broader implementation of advanced technologies. Adaptation forces employees to rethink their working habits and re-describe their role within the companies. Senior employees with long-term experience can participate in on-the-job training in an emerging field for changing their personal approach. Juniors and upcoming employees can even gain the necessary competencies by higher education in undergraduate or graduate programs. This also requires a change in learning and teaching approaches in universities.

Game-based learning, for instance, is one of the educational approaches to promote learning for digital transformation by setting goals, constraints, and payoffs. The serious game aims to teach undergraduate students factory planning, and later on how to manage the complexity of sustainable manufacturing by planning a factory.

2. Current Educational Programs related to "ENGINE"

The current educational programs in Electrical Engineering are examined in detail under two headings, world-wide and Europe, and insights to the future plans are also given with the help of the best examples.

2.1. Electrical Engineering Bachelor's Degree Programs related with "ENGINE" (World)

Universities that are subject to this research were chosen in regard to the 'QS World University Rankings 2021 by Subject: Engineering - Electrical and Electronics.

Table 1: QS World University Rankings 2021 by Subject: Engineering - Electrical and Electronic

Rank	University	Location	Faculty/ Department	Program
1	Massachusetts Institute of Technology	US	Electrical Engineering & Computer Science	Electrical Science and Engineering
2	Stanford University	US	Engineering	Electrical Engineering
3	University of California, Berkeley	US	Electrical Engineering & Computer Sciences	Electrical Engineering & Computer Science
4	Nanyang Technological University, Singapore	Singapore	School of Electrical and Electronic Engineering	Electrical and Electronic Engineering
5	National University of Singapore	Singapore	Engineering	Electrical and Computer Engineering
6	University of Cambridge	UK	Engineering	Engineering (specialization in electrical and electronic engineering)
7	ETH Zurich - Swiss Federal Institute of Technology	Switzerland	Engineering Sciences	Electrical Engineering and Information Technology

8	University of Oxford	UK	Engineering	Engineering (specialization in electrical and electronic engineering)
9	Imperial College London	UK	Department of Electrical and Electronic Engineering	Electrical and Electronic Engineering
10	EPFL	Switzerland	School of Engineering	Electrical Engineering
11	Harvard University	US	Department of Electrical Engineering	Electrical Engineering
12	Tsinghua University	China	Department of Electrical Engineering	Electrical Engineering
13	California Institute of Technology (Caltech)	US	Department of Electrical Engineering	Electrical Engineering
14	Georgia Institute of Technology	US	School of Electrical and Computer Engineering	Electrical Engineering
15	University of California, Los Angeles (UCLA)	US	Samueli Electrical and Computer Engineering	Electrical and Computer Engineering
16	Delft University of Technology	Netherlands	-	Electrical Engineering
17	Technical University of Munich	Germany	Department of Electrical and Computer Engineering	Electrical Engineering and Information Technology
18	KAIST - Korea Advanced Institute of Science & Technology	South Korea	Electrical Engineering	Electrical Engineering

2.1.1. Best Cases in the World

2.1.1.1 US: Massachusetts Institute of Technology (MIT)/ Electrical Science and Engineering

Electrical Engineering & Computer Science is the largest undergraduate program of MIT. Electrical Engineering at MIT is a very broad program that starts with basic circuit theory and moves into systems, physics of electronic devices, and quantum mechanics. The program offers a flexible curriculum and intensive, hands-on coursework with the aim of preparing students for success in a wide range of industries, from software to bioengineering and econometrics. The faculty is also focused on subjects critical to advancement in today's high-tech society such as artificial intelligence and robotics.

The department's faculty includes many renowned researchers and scholars, including more than 40 members of the National Academy of Engineering, more than 10 members of the National Academy of Sciences, several National Medal of Technology winners, several Turing Award winners, as well as many Fellows of professional societies, such as the IEEE, ACM, APS, AAAI, and others.

2.1.1.2 Singapore: Nanyang Technological University (NTU)/ Electrical and Electronic Engineering

NTU Electrical and Electronic Engineering program is ranked 1st in Asia. Students are taught by internationally renowned experts with a strong passion for the subject. Teaching staff have contributed to many innovations such as noise-cancelling device, high-resolution medical imaging device, and quantum dot lasers. Courses of the program encapsulate all the latest technological developments and the needs of the industry. The program offers exclusive employment opportunities.

Students have access to state-of-the-art facilities like EEE Garage, EEE Gallery and iHub, where they can explore new school projects with hands-on experiences. The program also offers the opportunity of benefitting from joint research laboratories with private companies.

Associate Degree of 'Electrical Engineering Technology'

Associate degrees in electrical engineering consist of two years and students are expected to complete 60 credits. Program courses may cover topics such as general and technical physics, engineering drawings, and electric circuits.

After the completion of the degree, graduates can pursue entry-level technician roles in areas such as electrical installation, electronics repair, and manufacturing. It is common for graduates to continue their education by completing a bachelor's.

Bachelor's Degree

2.1.2. Pre-requisites

2.1.2.1 United States

The SAT or the ACT is required for all undergraduate applicants. School report and counselor letter of recommendation, official transcript(s) or academic results, letters of recommendation from two teachers are requested for the application. The selection process is conducted by the merit order.

There are no departmental entrance requirements for admitted freshmen. Freshmen enter undeclared and typically choose a major at the end of their second semester. There are no prerequisites to declaring a major, but students who expect to join the electrical engineering program may wish to get started on the department's introductory classes during the freshman year.

2.1.2.2 Europe

There are different requirements for different high school qualifications (National, European, International). If a school-leaving degree from another country is not comparable to the university entrance qualification, direct admission can only be granted after attending preparatory studies and after having taken the university qualification assessment examination or the student must be finished one year at a Science University (in the country of origin) in a subject closely related to the BSc program of choice.

A minimum level of English and local language (Dutch, German etc.) proficiency is required.

Bachelor's degree programs in Europe usually consist of 3 years. Electrical engineering program specifically requires an A level in Mathematics and Physics.

Some programs require admission tests such as Physics Aptitude Test.

2.1.2.3 Singapore & South Korea

There are different requirements for different high school qualifications (A-level applicants, international baccalaureate applicants, polytechnic diploma from Singapore, applicants presenting international qualifications) presented for the application. Certain high school qualifications require applicants to submit either ACT with Writing or SAT, together with SAT Subject Tests scores. List of acceptable high school qualifications and their requirements are given on the program websites.

Electrical engineering program specific requirements are given as year 12 or higher-level pass in Mathematics and Physics or Chemistry.

A minimum level of English proficiency is required (IELTS Academic 6.5, TOEFL 92-93).

Outstanding achievements in co-curricular activities and competitions are also considered during the admission process.

2.1.3 Fundamental Courses

The first two years of the electrical engineering degree program focus on building the necessary foundations in the compulsory subjects such as Mathematics, Science, and Computer Science together with Electrical Engineering core courses. Students gain practical skills from the beginning of the program with lab sessions and group projects. In the following years of the program, students can specialize in an area with elective courses. Most of the top universities bring together electrical engineering and computer science, and also offer IT tools and programming courses with the possibility of going further with advanced elective courses.

Fundamental courses are Mathematics, Science (Physics), Technology in society, Computer Science, Programming, Circuits, Signals & Systems, Electro-magnetic Fields and Waves, Digital Systems, Computer Modelling

2.1.4 Necessary Laboratory Learning and Teaching Environments

Students undertake courses of laboratory experiments to provide the necessary grounding in the practical skills required from engineers. Substantial computational laboratory component explores the concepts introduced in class in the context of realistic contemporary applications

Lab components can be used for software design, construction, and implementation of the design. Universities diversify their laboratory capabilities by working with companies.

2.1.5 Learning Outcomes

Electrical Engineering graduates are expected to gain:

- An ability to apply knowledge of mathematics, science, and engineering to identify and solve complex engineering problems
- An ability to design and conduct experiments, as well as to analyze and interpret the obtained data
- An ability to design a system, component, or process to meet specified needs with consideration of realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- An ability to function on multi-disciplinary teams and to communicate effectively with a range of audiences

- An understanding of ethical and professional responsibilities in engineering situations and make informed judgments, with considerations of the impact of engineering solutions in global, economic, environmental, and societal contexts
- A knowledge of contemporary issues and applying new knowledge as needed
- Background for admission to further studies

2.1.6 Competences

- Technical skills: Graduates are expected to be technically competent to solve complex problems in electrical engineering and be able to adapt effectively in a fast changing environment.
- Laboratory and design skills: Graduates are expected to develop the basic skills needed to perform and design experimental projects.
- Critical thinking: Graduates are expected to be able to critically think, analyze and make decisions considering global issues, ethics, society, and the environment.
- Communication skills: Graduates are expected to be able to organize and present information, act with integrity and have interpersonal skills that give them the ability to function on multi-disciplinary teams
- Life-long learning attitude

2.1.7 Career Opportunities

Similar to other engineering graduates, electrical engineering bachelor's degree program graduates usually follow 3 different pathways which are research-focused, innovation & design focused, and practicing professional/industrial pathways.

Electrical engineering is a wide field, with many multi-disciplinary areas, which offers the opportunity of working on many positions to its graduates. The scope of electrical engineering is not limited to certain sectors; in fact, graduates can be employed by several employers with the aim of specializing their skillset further. Some graduates join large private companies, public companies, or service sectors, others work in research laboratories or get advanced degrees in other fields, including medicine and law. Electrical Products, Information & Communication, Public Administration & Defense, Engineering Manufacturing Financial services sector are top preferred sectors.

- Aerospace Industry - Aerospace Electrical Engineer
- Automotive Industry - Automotive Engineer
- Built Environment Industry - Contract Engineer
- Defense Industry - Military Engineer
- Electronics Industry - Electronic Engineers
- Retail Industry - Investment Analyst
- Marine Industry - Engineering Technician
- Power Generation Industry - Maintenance/Engineering Assistant

- Gas and Oil Industry - Test Engineer
- Rail Industry - Systems Engineer

US Bureau of Labor Statistics (2021) has projected the growth of overall employment of electrical engineers as 3 percent from 2019 to 2029, about as fast as the average for all occupations. Employment growth is expected to be tempered by slow growth or decline in some industries, such as manufacturing and utilities.

Table 2: Electrical Engineering Curriculum International Overview

University	Study Plan									Methodology		Quality	
	Options					Structure	EE Introduction	Capstone Course	Undergrad. Research	Engineering Skills	Comm. Skills	Assessment	Program Quality Tracking
	Comm.	Networks	Electronics	Image and Video	Other								
MIT	YES	YES	YES	NO		BS(4), BS+MS(5), MS(2)	YES	YES	YES	CDIO	4 courses	Warning flag	Permanent revision
Stanford	YES	YES	YES	NO	Independent study program	BS(4), MS(2)	YES	YES	YES	CDIO	Not explicitly	Withdrawing courses	Every 5 years
Berkeley	YES	YES	YES	NO	Independent study program	BS(4), BS+MS(5), MS(2)	YES	YES	YES	CDIO	Not explicitly	Withdrawing courses	Students' feedback
Columbia	YES	YES	YES	NO		BS(4), MS(2)	NO	YES	NO	CDIO	Not explicitly		
Wisconsin-Madison	YES	YES	YES	NO		BS(4), MS(2)	Optional	YES	YES	CDIO	Communication Skills Certificate		
Georgia Tech	YES	YES	YES	NO	Independent study program	BS(4), BS+MS(5), MS(2)	YES	YES	YES	CDIO	Not explicitly		
McGill	YES	YES	YES	NO		BS(4), MS(2)	NO	Final Project	YES	Research-based learning	Not explicitly		
Toronto	YES	YES	YES	NO		BS(4), MS(2)	YES	YES	YES				

University	Study Plan									Methodology		Quality	
	Options					Structure	EE Introduction	Capstone Course	Undergrad. Research	Engineering Skills	Comm. Skills	Assessment	Program Quality Tracking
	Comm.	Networks	Electronics	Image and Video	Other								
Auckland	YES	YES	YES	NO		BS(4), MS(2)	2nd Year	Final Project	NO	Research-based learning	Not explicitly	Teaching assessment	Permanent revision
Hong Kong Polytechnic	YES	YES	YES	NO		BS(4), MS(2)	NO	Final Project	NO	CDIO	Not explicitly	Continuous evaluation	
KAIST	YES	YES	YES	NO		BS(4), MS(2)	YES	Final Project			Elective courses		
TU München					General	BS(3), MS(2)	NO	Final Project	NO	CDIO	Not explicitly		
RWTH Aachen					General	BS(3-4), MS(2)	NO	Final Project	NO				
DTU						BS(3.5), BS+MS(5), MS(2)	NO	At the end of each term	NO	CDIO		ECTS criteria	
KTH	YES	YES	YES	YES		BS(3), BS+MS(5), MS(1,2)	NO	YES + Final Project	NO		Elective courses		
Telecom Paris					General	BS(3), MS(2)	NO	Industry Internship	NO	CDIO	2 courses		
Politecnico di Milano	YES	YES	YES	NO		BS(3), BS+MS(5), MS(2)	NO	Final Project	NO		Not explicitly		
ETH Zurich	YES	YES	YES	NO	Micro and opto electronics	BS(3), MS(2)	NO	Final Project	YES	CDIO	Not explicitly		

Source: Electrical Engineering Curriculum International Overview, UPC.

2.2. Electrical Engineering Bachelor's Degree Programs related with "ENGINE" (Europa)

Electrical engineering is an interdisciplinary form of engineering. Since the field is interdisciplinary the courses given should prepare the students for interdisciplinary subjects. Main courses such as mathematics, physics, electronics, electromagnetism, electromechanics, computer science, coding should be given at every undergraduate degree. One of the main roles of an electrical engineer is to construct an electrical device or maintain the functions of an electrical device, it is essential that mentioned courses are given.

2.2.1. Requirements for admission

In order to have a bachelor's degree first a student needs to get into a program. The requirements change throughout Europe since Europe has several countries which are not in the European Union such as Turkey, and Ukraine.

According to an official website of the European Union (EU), as a European Union (EU) citizen, a person is entitled to study at any European Union (EU) university under the same conditions as nationals. However, conditions of entry vary significantly between individual countries and universities. Also, knowledge of the host country's language may be required, so in some European Union (EU) counties the student may have to take a language test. [1]

Even countries that are in the EU differ in some details from one another when it comes to admission. For example, in Spain students holding any of the following certificates may have access to official Bachelor programs:

- Bachelor's certificate or equivalent certificate meaning diplomas from the education systems of the Member States of the European Union (EU). Also, from other States that have signed international agreements with Spain regarding this topic (students must meet the academic requirements established in their countries of origin).
- Official Bachelor's, Master's, or equivalent degree.
- Official Graduated, Technical Architect, Technical Engineer, Bachelor, Architect, Engineer degrees, corresponding to the previous organization of university education or equivalent degree

These admission requirements are established by public universities. And even the admission procedure and the criteria to take into account in each procedure depends on the certificate of the individual.

2.2.2. Best Cases in the European Union

2.2.2.1. UK: University of Cambridge

Data taken from mastersportal.com and QS Rankings according to the best electrical engineering schools and universities in Europe in 2021 is **University of Cambridge, UK**

- **Undergraduate overview**

The university offers a program that normally lasts 4 years leading to two degrees: BA (with honors) and MEng. The first two years of the program cover mechanical, structural, materials, electrical, and information engineering in a broad brush. After taking generalized courses for 2 years students are required to specialize. At the end of the third year, the students qualify for a BA (with honors). But Cambridge's program is designed with a 4-year structure leading to a master's degree.

- **Learning outcomes**

Engineering is a very broad term in modern times, engineers are involved in every step of designing and manufacturing nearly everything that comes to mind. From designing cars to manufacturing them, constructing buildings, producing new medical gadgets, making microchips, advancing energy harvesting systems to many more that can come to mind. This means that when an individual studies engineering or electrical engineering for this instance, the individual has open options. According to the University of Cambridge's Department of Engineering, an engineer has broad scientific and engineering background and more importantly a deep understanding of the subject in which an individual can specialize in. the learning outcomes can be given as:

- the ability to apply problem-solving strategies
- a creative approach
- team-working skills
- mathematical and computing skills
- the ability to analyze data
- written and oral communication and presentation skills
- research skills

- **Career Opportunities**

People graduating from electrical engineering can find jobs in diverse sectors such as;

- Automotive engineering
- Defense
- Aerospace
- Life sciences
- Power generation
- Energy generation
- Manufacturing
- Civil engineering
- Software engineering
- Data science
- Technical consultant
- IT
- Electrical and electronic engineering
- Biomedical engineering
- Materials science
- Energy and utilities
- Academic, researcher

In the United Kingdom (UK) graduates' salary is usually 24-35k pounds. In fields such as power, energy, defense, technical consultant, and IT may pay more. [4]

The table is given below shows data for types of work entered in the UK. [9]

type of work	*Percentage*
Engineering and building	42.8
Information technology	23.6
Technicians and other professions	6
Retail, catering and bar staff	4
Other	23.6

2.2.2.2. Netherlands: University in Netherlands, and Germany: Eindhoven University of Technology

A graduate of electrical engineering can focus on research as a career path can start working in universities. A university in the Netherlands, Eindhoven University of Technology has a research department of electrical engineering. This department focuses on three areas:

- **The connected world research program**

It has two dedicated research centers: COBRA (optical communication) and Center for Wireless Technology Eindhoven (CWTe).

- **Smart sustainable society program**

This program focuses on corona plasma technology. This technique cleans air of odors and harmful matter.

- **Care and cure program**

This program has several research projects such as smart jacket for premature babies, electrode patch for predicting premature birth, and delivery simulation center. [5]

An advantage of working in research departments is that companies surrounding the topic will cooperate with your department and that can only be beneficial for the individual.

An electrical engineer in Germany as an entry-level employee with less than 1-year experience can earn 24k euro. [6] The career path an individual can take in Germany is the same as any other European Union (EU) country. But since Germany is a leading country even among other EU countries the average salary for an entry-level employee is expected to be higher.

An entry-level electrical engineer usually takes 3 different approaches to advance in their career.

- Senior electrical engineer
  - Electrical engineer
  - Product engineer
- Project engineer
- Hardware engineer

The most common path taken is becoming a senior electrical engineer, afterwards becoming an experienced electrical engineer. More than 20% take this course of action. [7]

What determines the salary for the engineer is the experience level. Raise in payment drastically changes when the individual's level of expertise is visibly advancing. After 2 years of being in the industry, an electrical engineer can expect up to 30-55k euro. These salaries increase even further if the individual has also a master's degree by 93%. Since pay increase is significant, the investment can be recovered in only a year. [6]

Most common practices for electrical engineers in Germany can be listed as: [8]

- Power electronics engineer
- Electronic technician
- Electrical and electronics engineer

- PLC programmer
- Electronic design engineer
- Industrial maintenance technician
- Electrical design engineer for analog electronics
- Field service technician

3. Needs for Improvement in the current programs

The integration of a broad range of social perspectives and technology challenges into university engineering education and research programmes is key. Such interdisciplinary work across engineering, social sciences, sciences, and the humanities must be firmly embedded in university engineering programmes related to energy. It must also be more than an add-on. It requires all academic disciplines to recognize that energy-related perspectives backed by knowledge from all disciplines bring value to energy solution development and help achieve real progress and change. This interdisciplinary approach must also span a range of technical areas. After all, a holistic approach needs to address all components of the future smart system with an understanding of the social and human interactions at play.

In this perspective, students that graduate with new profiles should include: Energy System Informations, Energy Economics, and Energy Policy Making. All skills will contribute to developing solutions to the energy challenge. One of the major specializations for electrical engineers – and among the most important issues for modern society – is power generation and distribution. Specializations in this field should prepare students for work across a range of stages in the power system, from designing energy generation and conversion facilities, to managing the supply of energy to individual users and devices. Students may choose to further specialize in a particular type of energy sources, such as wind or solar power.

4. New IT tools to be included

- **Autocad Electrical Toolset** (2D), **SolidWorks** (3D) are useful cad tools for designing mechanical products, and these two tools are generally mentioned as a requirement for jobs applications in electrical design engineering. [1] Especially proficiency of Autocad is a plus by many companies on LinkedIn.
  (on LinkedIn there are 2.273 job adds while searching "autocad electrical", and 733 on LinkedIn job adds related to "solidworks electrical" keywords in European Union)

[1] https://www.smlease.com/entries/cad/difference-between-autocad-and-solidworks-autocad-vs-solidworks/

- **DIALux** is the tool which helps lighting designers select and evaluate lighting systems. With the program, the users plan the lighting in a room, scene or building. Dialux will calculate and visualize the daylight. While the projects plan properly, DIALux enables the energy your light solution requires *(150 – "dialux electrical" on LinkedIn)*
- **ETAP (Electrical Transient and Analysis Program**) is a software program for electrical engineers. It supplies power systems solutions including Generation, Transmission, Distribution, Transportation, Industrial, and Commercial sectors. [2] ETAP is the most comprehensive analysis platform for the design, simulation, operation, and automation of generation, distribution, and industrial power systems. [3] *(1024 job results while searching with "ETAP" on LinkedIn)*
- **MATLAB** and **Simulink**: MATLAB is a multiparadigm numerical computing environment and proprietary programming language developed by MathWorks. Simulink is a MATLAB-based graphical programming environment for modeling, simulating and analyzing multi domain dynamical systems.[4] Power electronics engineers use MATLAB and Simulink to develop digital control systems for motors, power converters, and battery systems.[5] *(1.079 results for "MATLAB and electrical on LinkedIn)*
- **DigSLIENT** Power Factory is one of most popular system analysis software applications for use in analyzing generation, transmission, distribution, and industrial systems.[6] *(105 results for "digsilent" on LinkedIn)*
- **PSCAD** is used for building, simulate, and modelling the systems with ease, providing limitless possibilities in power systems simulation. *(70 results with "PSCAD")*
- **PSS/E (Power System Simulator for Engineering)** is helpful for planning and operations engineers, consultants, universities, and research labs around the world. It allows you to perform a wide variety of analysis functions, including power flow, dynamics, short circuit, contingency analysis, optimal power flow, voltage stability, transient stability simulation, and so on.[7] *(104 results with PSS/E on LinkedIn)*
- **PLS CADD (Power Line Systems - Computer Aided Design and Drafting)-** PLS-CADD is a widely used power line design program on the market.[8] (*27 results for "pls cadd" on LinkedIn)*
- **EPLAN Electric P8: Power for electrical planning and engineering** is a consistent, integrated, and fast engineering system to plan and design the electrical engineering for machines and plant systems. [9](*108 results with "EPLAN Electric P8" on LinkedIn)*

[2] https://etap.com/docs/default-source/brochures/etap-solutions-overview.pdf?sfvrsn=88144c7c_60
[3] https://electrical-engineering-portal.com/download-center/electrical-software/etap
[4] https://ctms.engin.umich.edu/CTMS/index.php?aux=Basics_Simulink
[5] https://www.mathworks.com/solutions/power-electronics-control.html
[6] https://www.digsilent.de/en/powerfactory.html
[7] https://new.siemens.com/global/en/products/energy/energy-automation-and-smart-grid/pss-software/pss-e.html
[8] https://www.powerlinesystems.com/plscadd
[9] https://www.eplan-software.com/solutions/eplan-platform/eplan-electric-p8/

- **SCADA** systems are mainly used for the implementation of monitoring and control systems of an equipment or a plant in several industries like power plants, oil and gas refining, water and waste control, telecommunications, etc. *(118 results with "scada power" on LinkedIn)*
- In addition to the tools, **C, C++, Java, Phyton, Jira, SourceTree** programming languages are mentioned in software and programming skills in job adds. [10]
- Rarely mentioned software programs: **Cyme, Arm Keil, Neplan (ABB)** etc.
- There are some youtube videos which grades IT tools on electrical engineering such as https://www.youtube.com/watch?v=f6e2TRzIJSs ; https://www.youtube.com/watch?v=cv9Y0iPzyDU ; https://www.youtube.com/watch?v=MVmE3oMVrXE

5. Tailoring educational programs according to job market in energy sector

Climate change, air quality and energy security will change the way energy is used and supplied over the next century. Supplying increasing amounts of clean and secure energy will be a challenge that will require a great deal of innovation and investment. There are plenty of resource and technology options that could lead to emissions reductions in the heat, transport and electricity sector, while improving energy security. Several clean energy options are viable today and several others are likely to be so in the future, as technologies improve, costs are reduced, and the competitive landscape for energy technologies evolves. Fighting climate change and energy security requires the simultaneous deployment of available commercial clean technologies, demonstration and commercialization of technologies at the advanced research, development and demonstration stage, and research into new technologies. In this sense, renewable energy and energy efficiency technologies and engineers are the key for creating a clean energy future for the world.

While climate changes threaten national infrastructure and the economy, engineers try to mitigate effects of climate change or adapt to the changing climatic conditions. Therefore, they have to play a major role in minimizing its effects. Adapting to climate change is not just a matter of managing the risks, it is about taking the opportunities it presents to develop new, innovative infrastructure systems and services. Adaptation to, and mitigation of, climate change provides opportunities in the new green economy. New opportunities in engineering design and manufacturing will come from the development of renewable energy technologies and the supply chains that will serve them. Building of resilience into existing infrastructure and designing new systems that are robust is the order of the day and thus to be taught to students. Investment in infrastructure adaptation will create quality jobs, increasing the demand for skilled technicians who need to install, upgrade and maintain the new resilient infrastructure. It requires individuals, organizations and businesses to take a realistic view of the future reliability of infrastructure-based services.

[10] https://www.researchgate.net/post/If-someone-intends-to-learn-a-new-programming-language-specifically-for-Electrical-Engineering-applications-which-one-do-you-suggest-and-why

Engineering educators have to skill students to be able to work most of the companies in future tend to create virtual digital processes (3d manufacturing environments) or digital 3d working environments. As digital transformation sweeps across the industry, engineering educators should think of appropriate skills to support, maintain, manage and advance this transformation. As the future of the economies depend on Innovation and digital transformation, engineering educators should think of how undergraduate students can be equipped with skills to innovate, support and bring innovation into the products, processes and services.

The curriculum should offer appropriate courses, schemes, process, opportunities, interactions, experiences for the students to understand future workplaces, environments and products and problem solving through teams in an entrepreneurial or start-up culture in collaborative ways. Students need to be taught appropriate designing, innovating and entrepreneurial skills, without which start-ups cannot be successful. Engineering educators and institutions should disrupt the existing processes and invent and innovate new processes so that the undergraduate engineers could be produced to match the needs of digitally transformed industries. Skilling large numbers in short times can only be achieved by radical disruptive thinking and bold execution through synergy between multiple stakeholders, academia, companies, students, young professionals and governments. Engineering education should switch over from classroom based real environments to virtual learning environments based on IT where students can learn through virtual laboratories.

Engineering education should expose students to system thinking, biodiversity, equity, ecological footprints, environmental space, through interaction with activities on communities and development. For this to happen faculty should be involved in collaborative projects with and linkages across departments, universities and organizations, in the areas like urban studies, economics, and social sciences.

Nearly 58 million people worldwide were employed in the energy sector in 2017. Although about half of these jobs were in the fossil fuel industries, renewable energy employment is increasing globally, reaching 11 million total jobs in 2018. It is expected that renewable energy jobs can reach 42 million by 2050. [11]

In the EU, there are almost 500 thousand workforces in the coal industry and while future projections examined this number will dramatically decrease to 340 thousand. In this case renewable energy will play a key role for recovery. For example, in the geothermal sector a need will occur for the mining sector, so the importance of geologists and engineers, geophysicists, geochemists, technicians, maintainers. As well as engineering in geosciences, electrical engineers can be requalified to work with

[11] https://ec.europa.eu/jrc/en/science-update/employment-energy-sector

the innovative plasma-based drilling technology in the geothermal sector. Electrical and mechanical skills, experience in the coal industry working under difficult conditions have been valued highly by the wind and solar PV sectors.[12]

A full implementation of the Paris agreement would create additional 1.2 million jobs in the EU by 2030. This job creation is expected to take place mostly in greening sectors, including construction, waste management and sustainable finance. In addition to that energy efficiency renovations will create 2.3 million demand by 2030. While the future projections are examined in the energy market, it is expected that traditional jobs and engineering programs maintain their importance such as subsurface and surface engineering on the oil and gas market. In the near future, Science Technology Engineering and Mathematics (STEM) skills are generally preferred in the energy sector, and in the clean energy transition. STEM skills include technology researchers at the manufacturing stage of the value chain, electrical, process and structural engineers in project planning, and field technicians in operation and maintenance. Also, IT skills gained importance not only in high and middle skill jobs but also in lower skill jobs as well such as low-skilled machinist, as well as construction and transport workers.[13]

There are some challenges for the energy sector or market, such as:

Challenges faced in European Union by EEE

- Production, since Asia is advancing in product development and research, European nations start to have shortage of engineers.
- Due to cheaper production outside of Europe loss of skilled labor increases.
- Access to credit form financial institutions.
- Lack of progress in energy supply infrastructure.
- Lack of progress in energy efficiency.
- Investments in research and development (R&D) has to increase in order to compete with the USA, Japan and China.
- The development of smart technologies.
- Low-tech/low-cost market areas' compliance gets less attention due to price pressure.
- Brexit.

[12] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/eu-coal-regions-opportunities-and-challenges-ahead
[13] https://ec.europa.eu/jrc/en/publication/eur-scientific-and-technical-research-reports/employment-energy-sector

Considering these difficulties above, in order to control the share of electrical engineers or other engineering fields related to energy in the energy sector, it is necessary to turn to more innovative and market-oriented project-based training that takes industrial-university cooperation.

What do electrical and electronic engineering graduates do?

While top jobs for electrical and electronics engineering graduates include engineering professions, the most common form of employment for graduates after 15 months is as programmers and software development professionals. [9]

Destination	*Percentage*
Employed	72.6
Further study	11.6
Working and studying	6.2
Unemployed	5.5
Other	4.1

This table presents data for graduate destinations for electrical and electronics engineers. [9]

Electrical and electronics engineering industries (EEI)

European Union (EU) policies affecting electrical and electronics engineering industries (EEI) cover three significant areas: [10]

- Electromagnetic compatibility
  Covers all equipment that generates electromagnetic waves, pulse, field, interference or covers all equipment that can be affected by electromagnetic disturbances. Regulated by the electromagnetic compatibility directive (EMC). [11]

- Low voltage electrical equipment
  Covers health and safety risks caused by electrical equipment of specific voltage ranges. Regulated by the low voltage directive (LVD). [12]

- Radio and telecommunication terminal equipment
  Applies to all products using radio-frequency spectrum. Regulated by the radio equipment directive (RED). [13]

6. Conclusions

One of the key factors for the advancement of electrical engineering departments especially in the energy sector is greater cooperation. Collaboration between universities that are successful according to various approved ranking studies and those in other categories, or universities in different categories is required, cooperation between universities and industry, between universities and policy makers, and between universities and communities through outreach will increase the sectoral success of the department.

Especially when looking at universities that are among the best practices, an important common university vision should be put forward in order to improve the teaching and research programs advocated in the ENGINE project. This common vision should be developed collaboratively to ensure that all parties benefit. The proposed changes in university structures should also help them be more flexible to address the challenges associated with the need for collaboration and development at community pace.

Postgraduate collaboration opportunities between universities are practically unlimited. For this reason, some scenarios should be developed only for the energy-related collaborations between universities. In particular, the opinions of all stakeholders should be taken, and a curriculum should be developed accordingly.

Benefits should be gained by increasing the cooperation between universities and stakeholders regarding energy into the future. Especially living laboratories, municipalities - Urban centers and other communities can create a testing ground for new technologies, processes and strategies, and help municipalities, companies, government to provide better services.

Market conditions for electrical engineering graduates can be improved by cooperating with large-scale implementation and roadmap studies. Collaborations of energy system / efficiency companies can be made - Collaboration with companies that design, manufacture and / or market energy products and services can lead to higher quality goods and more market penetration, thus increasing job opportunities for graduates. In addition, curricula can be developed by paying attention to the details given in the content of the report, which will allow students to easily transition from academia to the private sector and the private sector to recruit well-educated employees.

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